RESEARCH HIGHLIGHTS

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INDOOR PARTICULATE AND FLOOR CLEANING

Introduction

Recent research has identified a relationship between short-term respirable[1] and inhalable[2] fine particle matter (PM) exposures and health outcomes. Indoor fine particles can consist of dander, allergens, chemical substances, mineral particulate, viruses and bacteria. Given that the portion of time spent indoors exceeds 90% for most individuals, indoor exposures to fine particles may be more important than outdoor from a total dose point of view. It can be argued that, a large portion of a person's exposure to sensitizing, irritating or toxic substances comes from the resuspension of particles inside the home. Researchers have shown that higher exposure to PM occurs with in-home activities such as cleaning or walking especially if taking place on carpeted floors.

Homeowners are presented with an array of advice as to type of flooring, type of cleaning product and cleaning methods that would best reduce their personal exposure to PM. This advice comes from the commercial sector (advertising, product claims) as well as the care-giving sector (medical doctors, public health providers). In the case of a person who is suffering from a medical condition such as asthma, COPD, allergies or chemical sensitivities, this type of advice can be considered to be medical advice.

The conventional approach to evaluating cleaning effectiveness involves seeding the floor with a known weight of artificial dust. The floor surface is cleaned and the mass of dust remaining is measured. It is possible that the artificial dust does not represent respirable and inhalable PM size fractions appropriately and that the method does not evaluate the extent to which PM is likely to be resuspended from the surface into the breathing zone of the occupants by normal activity.

Some cleaning effectiveness studies have measured the PM remaining on a surface after cleaning and the airborne PM during cleaning. Other studies evaluated airborne PM change after cleaning by measuring the 8-hour average of PM resuspended by the activity of the house occupants. This approach may be more representative of the exposure of occupants but the results may be influenced by the variable nature of occupant activity.

Research Program

The objective of this study is to evaluate several cleaning methods on several surfaces with respect to their relative effect on the PM exposure of an individual living in the home. Secondarily, the study seeks to demonstrate a new approach to evaluation of floor cleaning methods by using a "standard activity" to quantify PM resuspension from the floor on the premise that more effective cleaning would result in less resuspension after cleaning.

The first stage of the project involved development of a "simulated activity". Six methods were tried and two methods were selected for use in the balance of the study as follows:

1) *Battery-Powered Vacuum and Remote-Controlled Vehicle:*

   A battery-powered remote control vehicle was modified to drag a modified battery-powered vacuum cleaner for fifteen minutes in a repeating pattern. The researcher controlled the movement of the vehicle while stationed in one corner of the room. This method was restricted by the turning radius of the remote-controlled vehicle and was used only in house 2.

[1] Particulate matter less than 2.5 m m, also called PM2.5

[2] Particulate matter less than 10 m m, also called PM10

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2) *Battery-Powered Vacuum and Walk-about:*

The modified battery-powered vacuum cleaner used in method 1 was moved in a repeating pattern around the room by a researcher at a "walking" pace for 15 minutes. This method was used in all houses except house 2.

All of the experiments are based on five homes in Brantford Ontario and the test conditions replicate typical southern Ontario Canadian spring, fall and winter conditions. The cleaning devices were employed in a manner which is representative of normal cleaning practice. Over 1300 experiments involving six powered cleaning devices (vacuum cleaners) and four non-powered cleaning devices were carried out. The specific devices are described in Tables 1 and 2.

The experiments consisted of carrying out the "simulated activity" prior to cleaning, cleaning of the floor and repetition of the simulated activity immediately following cleaning. Cleaning was carried out weekly in one room of each house by the same operator using a different device each week. At a pre-determined point in the sequence, the carpeted floor was replaced by a smooth floor and the cleaning program was repeated.

TABLE 1
Powered Cleaning Devices

Code	Type	Description	Notes
V1	Filter canister	"Samsung Quiet Storm" cannister model VAC9013BP, bag, 5 stage filter system, electric power brush, hand tools	Top-rated cannister vacuum in Consumer Reports[1]
V2	Ordinary upright	"Panasonic QuickDraw" upright model MC 5315C, bag, exhaust filter, beater bar	Example of an ordinary vacuum with regular bag and no special features
V3	HEPA bagless	"Phantom Lightning" model LC91 31, stair cannister model, bagless, HEPA filter, exhaust filter, power brush can be turned on and off, hand tools	Example of HEPA cannister vacuum
V4	Central	"Broan Central Vacuum" model V23C, collection cannister, no bag, exhaust to outside, power brush, w/on-off switch, hand tools	Typical central vacuum
V5	Filter upright	"Hoover Wind-tunnel Supreme" model U5450-955, upright vacuum, 3 layer filter bag, 2 layer exhaust filter, hand tools	Replaced top-rated upright tested (Ultra) by Consumer's Reports[2]
V6	Wet vacuum	"Hoover Steam Vac Supreme" model F839-900, Wet/Dry Upright Vacuum, Dirty water collection bucket, No filter per se., 1 hand tool	Example of "wet vacuum"
V7	Dirt-finder upright	"Hoover Wind-tunnel Supreme" model U5450-955, upright vacuum, as for V5 except operated until embedded dirt finder (indicator light) changed to "no dirt" indication	see V5

TABLE 2
Non-Powered Cleaning Devices

Code	Type	Description	Method
B1	Dry pad	"Swiffer" disposable dry cloths inserted onto stick broom with articulating pad	Swipe floor with 2 strokes and move to next area. Use one per room.
B2	Wet pad	"Swiffer Wet" disposable damp cloths inserted onto stick broom with pad	Swipe floor with 2 strokes and move. Use 1 per room
B3	Dust mop	Cedar "Zoom a-Lon". Yellow cotton yarn attached to removable articulating head that can be removed to be washed	Swipe floor with 2 stroke and move to next area. Pick up any dust piles not on mop.
B4	Broom	"Rubbermaid" angled polybristle broom	Sweep 2 strokes towards cleaner, lift and move to next area. Pick up dust pile

Findings

Results show that carpeted floors exhibit higher levels of PM resuspension during cleaning than smooth floors in all size ranges except that this tendency is not so pronounced for very fine (PM1) particles (See Figure 1).

The ordinary house broom (B4) was found to have high PM resuspension rates during use, but the cleaning effectiveness was similar to other devices. Dry or wet pad smooth floor sweeping devices were not found to have better effectiveness than a conventional dust-mop.

The tendency for a floor to accumulate PM10 and PM5 particles over time appears to be much more pronounced for carpeted floors than for smooth floors and also varies greatly from house to house and room to room. This was determined by the difference of the "post-clean" resuspension in one week and the "pre-clean" resuspension the week following in the same location. (See Figure 2).

Based on limited data, it appears that new carpet exhibits lower PM resuspension rates than old carpet and slightly higher PM resuspension rates than smooth floors. It is possible that the higher accumulation rate for carpets is responsible for their higher resuspension rates with aging (See Figure 3).

Higher-cost vacuum cleaners with special filters and other features were not found to have higher performance than other devices except in one limited case. When cleaning effectiveness on smooth floors after 1 week's elapsed time was evaluated, it was found that the ordinary upright vacuum cleaner (V2) had higher cleaning effectiveness than all of the other cleaning devices.

Other than the performance of the ordinary upright vacuum cleaner, there was no apparent difference between the performance of vacuum cleaners and sweeping devices on smooth floors.

There were no trends for the floors to become cleaner with time. In order to produce a meaningful reduction in particle resuspension, it appears that cleaning will have to be more frequent and or more vigorous than the weekly cleaning used for this study.

The experimental method produced some useful results, however the research team concluded that minor changes to the experimental method would significantly reduce uncertainties and result in more useful data in future experiments.

[3] Consumers Report January 2001

[4] Consumers Report January 2001

Figure 1. Peak PM during cleaning, all devices, all surfaces, c = carpet, s = smooth, n= 4+

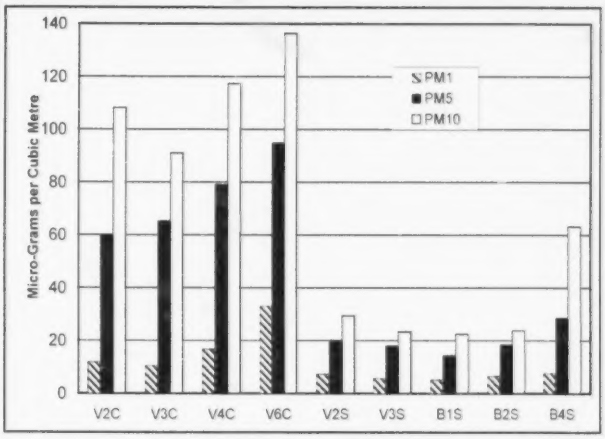


Figure 2. PM accumulation for one week, house 1 & 2, all surfaces, c = carpet, s = smooth, n= 4+

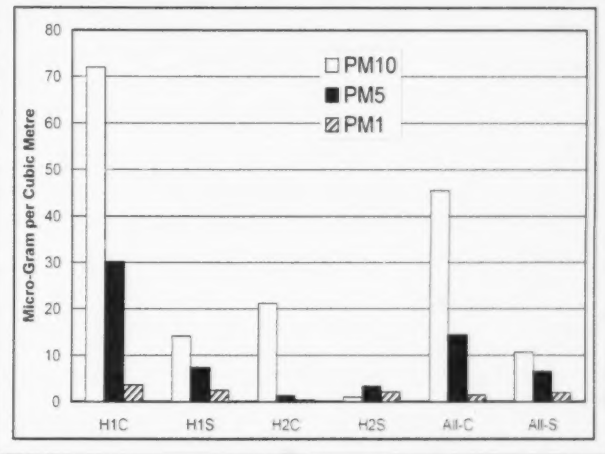
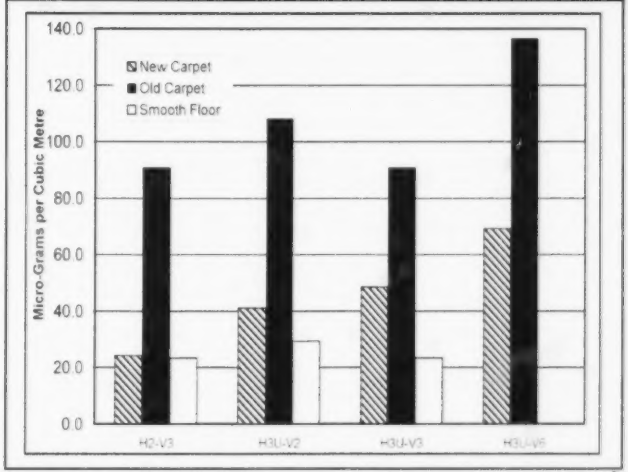


Figure 3. PM 10 Peak during cleaning, new carpet vs. old carpet and smooth floor, limited data



Implications for the housing industry

There are clear differences between smooth and carpeted floors with respect to the fine particles which are re-suspended by cleaning and normal activity. Particle re-suspension is significantly less for smooth floors when compared to old carpet and it appears that this may also be true to a lesser for new carpet.

Weekly vacuuming in a manner that is normally practiced is probably not sufficient to produce a meaningful reduction in particle re-suspension rates. Vacuuming and/or cleaning will probably have to more vigorous and/or more frequent, but the research did not identify the frequency or degree of vigor that would be required.

Significant differences in cleaning performance between devices were not noted although many of the devices were claimed to be more effective than others. Some difference in particle resuspension during cleaning was noted and the tendency for an ordinary broom to "stir up the dust" should be noted by persons who are sensitive to components of household dust.

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Housing Research at CMHC

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